Supplementary Material I – UDL Checkpoint Operationalizations

The table below presents the UDL checkpoints and examples of implementation from the UDL Guidelines 2.0.\textsuperscript{[1]} The UDL implementation examples and descriptions were used as the operationalizations of the UDL checkpoints in this study.

<table>
<thead>
<tr>
<th>Description</th>
<th>Checkpoint</th>
<th>Implementation Example</th>
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<tbody>
<tr>
<td>Offer ways of customizing the display of information</td>
<td>1.1</td>
<td>• Display information in a flexible format so that the following perceptual features can be varied:</td>
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<td></td>
<td></td>
<td>• The size of text, images, graphs, tables, or other visual content</td>
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<tr>
<td></td>
<td></td>
<td>• The contrast between background and text or image</td>
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<td></td>
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<td>• The color used for information or emphasis</td>
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<td>• The volume or rate of speech or sound</td>
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<td></td>
<td>• The speed or timing of video, animation, sound, simulations, etc.</td>
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<td>• The layout of visual or other elements</td>
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<td>• The font used for print materials</td>
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<tr>
<td>Offer alternatives for auditory information</td>
<td>1.2</td>
<td>• Use text equivalents in the form of captions or automated speech-to-text (voice recognition) for spoken language</td>
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<td></td>
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<td>• Provide visual diagrams, charts, notations of music or sound</td>
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<td>• Provide written transcripts for videos or auditory clips</td>
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<td>• Provide American Sign Language (ASL) for spoken English</td>
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<td>• Use visual analogues to represent emphasis and prosody (e.g., emoticons, symbols, or images)</td>
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<td>• Provide visual or tactile (e.g., vibrations) equivalents for sound effects or alerts</td>
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<td>• Provide visual and/or emotional description for musical interpretation</td>
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<td>Offer alternatives for visual information</td>
<td>1.3</td>
<td>• Provide descriptions (text or spoken) for all images, graphics, video, or animations</td>
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<td>• Use touch equivalents (tactile graphics or objects of reference) for key visuals that represent concepts</td>
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<td>• Provide physical objects and spatial models to convey perspective or interaction</td>
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<td>• Provide auditory cues for key concepts and transitions in visual information</td>
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<td>• Follow accessibility standards (NIMAS, DAISY, etc.) when creating digital text</td>
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<td></td>
<td>• Allow for a competent aide, partner, or “intervener” to read text aloud</td>
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<td></td>
<td>• Provide access to text-to-Speech software</td>
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<td>Description</td>
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| Clarify vocabulary and symbols | 2.1 | • Pre-teach vocabulary and symbols, especially in ways that promote connection to the learners’ experience and prior knowledge  
• Provide graphic symbols with alternative text descriptions  
• Highlight how complex terms, expressions, or equations are composed of simpler words or symbols  
• Embed support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations)  
• Embed support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect) |
| Clarify syntax and structure | 2.2 | • Clarify unfamiliar syntax (in language or in math formulas) or underlying structure (in diagrams, graphs, illustrations, extended expositions or narratives) through alternatives that:  
• Highlight structural relations or make them more explicit  
• Make connections to previously learned structures  
• Make relationships between elements explicit (e.g., highlighting the transition words in an essay, links between ideas in a concept map, etc.) |
| Support decoding of text, mathematical notation, and symbols | 2.3 | • Allow the use of Text-to-Speech  
• Use automatic voicing with digital mathematical notation (Math ML)  
• Use digital text with an accompanying human voice recording (e.g., Daisy Talking Books)  
• Allow for flexibility and easy access to multiple representations of notation where appropriate (e.g., formulas, word problems, graphs)  
• Offer clarification of notation through lists of key terms |
| Promote understanding across languages | 2.4 | • Make all key information in the dominant language (e.g., English) also available in first languages (e.g., Spanish) for learners with limited-English proficiency and in ASL for learners who are deaf  
• Link key vocabulary words to definitions and pronunciations in both dominant and heritage languages  
• Define domain-specific vocabulary (e.g., “map key” in social studies) using both domain-specific and common terms  
• Provide electronic translation tools or links to multilingual glossaries on the web  
• Embed visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc.) |
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| Illustrate through multiple  | 2.5        | • Present key concepts in one form of symbolic representation (e.g., an expository text or a math equation) with an alternative form (e.g., an illustration, dance/movement, diagram, table, model, video, comic strip, storyboard, photograph, animation, physical or virtual manipulative)  
• Make explicit links between information provided in texts and any accompanying representation of that information in illustrations, equations, charts, or diagrams |
| Activate or supply background| 3.1        | • Anchor instruction by linking to and activating relevant prior knowledge (e.g., using visual imagery, concept anchoring, or concept mastery routines)  
• Use advanced organizers (e.g., KWL methods, concept maps)  
• Pre-teach critical prerequisite concepts through demonstration or models  
• Bridge concepts with relevant analogies and metaphors  
• Make explicit cross-curricular connections (e.g., teaching literacy strategies in the social studies classroom) |
| Highlight patterns, critical  | 3.2        | • Highlight or emphasize key elements in text, graphics, diagrams, formulas  
• Use outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to emphasize key ideas and relationships  
• Use multiple examples and non-examples to emphasize critical features  
• Use cues and prompts to draw attention to critical features  
• Highlight previously learned skills that can be used to solve unfamiliar problems |
| Guide information processing,| 3.3        | • Give explicit prompts for each step in a sequential process  
• Provide options for organizational methods and approaches (tables and algorithms for processing mathematical operations)  
• Provide interactive models that guide exploration and new understandings  
• Introduce graduated scaffolds that support information processing strategies  
• Provide multiple entry points to a lesson and optional pathways through content (e.g., exploring big ideas through dramatic works, arts and literature, film and media)  
• “Chunk” information into smaller elements  
• Progressively release information (e.g., sequential highlighting)  
• Remove unnecessary distractions unless they are essential to the instructional goal |
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| Maximize transfer and generalization    | 3.4        | • Provide checklists, organizers, sticky notes, electronic reminders  
• Prompt the use of mnemonic strategies and devices (e.g., visual imagery, paraphrasing strategies, method of loci, etc.)  
• Incorporate explicit opportunities for review and practice  
• Provide templates, graphic organizers, concept maps to support note-taking  
• Provide scaffolds that connect new information to prior knowledge (e.g., word webs, half-full concept maps)  
• Embed new ideas in familiar ideas and contexts (e.g., use of analogy, metaphor, drama, music, film, etc.)  
• Provide explicit, supported opportunities to generalize learning to new situations (e.g., different types of problems that can be solved with linear equations, using physics principles to build a playground)  
• Offer opportunities over time to revisit key ideas and linkages between ideas |
| Vary the methods for response and navigation | 4.1        | • Provide alternatives in the requirements for rate, timing, speed, and range of motor action required to interact with instructional materials, physical manipulatives, and technologies  
• Provide alternatives for physically responding or indicating selections (e.g., alternatives to marking with pen and pencil, alternatives to mouse control)  
• Provide alternatives for physically interacting with materials by hand, voice, single switch, joystick, keyboard, or adapted keyboard |
| Optimize access to tools and assistive technologies | 4.2        | • Provide alternate keyboard commands for mouse action  
• Build switch and scanning options for increased independent access and keyboard alternatives  
• Provide access to alternative keyboards  
• Customize overlays for touch screens and keyboards  
• Select software that works seamlessly with keyboard alternatives and alt keys |
| Use multiple media for communication     | 5.1        | • Compose in multiple media such as text, speech, drawing, illustration, design, film, music, dance/movement, visual art, sculpture or video  
• Use physical manipulatives (e.g., blocks, 3D models, base-ten blocks)  
• Use social media and interactive web tools (e.g., discussion forums, chats, web design, annotation tools, storyboards, comic strips, animation presentations)  
• Compose in multiple media such as text, speech, drawing, illustration, comics, storyboards, design, film, music, visual art, sculpture, or video |
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| Use multiple tools for construction and composition | 5.2 | • Provide spellcheckers, grammar checkers, word prediction software  
• Provide Text-To-Speech software (voice recognition), human dictation, recording  
• Provide calculators, graphing calculators, geometric sketchpads, or pre-formatted graph paper  
• Provide sentence starters or sentence strips  
• Use story webs, outlining tools, or concept mapping tools  
• Provide Computer-Aided-Design (CAD), music notation (writing) software, or mathematical notation software  
• Provide virtual or concrete mathematics manipulatives (e.g., base-10 blocks, algebra blocks)  
• Use web applications (e.g., wikis, animation, presentation) |
| Build fluencies with graduated levels of support for practice and performance | 5.3 | • Provide differentiated models to emulate (i.e. models that demonstrate the same outcomes but use differing approaches, strategies, skills, etc.)  
• Provide differentiated mentors (i.e., teachers/tutors who use different approaches to motivate, guide, feedback or inform)  
• Provide scaffolds that can be gradually released with increasing independence and skills (e.g., embedded into digital reading and writing software)  
• Provide differentiated feedback (e.g., feedback that is accessible because it can be customized to individual learners)  
• Provide multiple examples of novel solutions to authentic problems |
| Guide appropriate goal-setting | 6.1 | • Provide prompts and scaffolds to estimate effort, resources, and difficulty  
• Provide models or examples of the process and product of goal-setting  
• Provide guides and checklists for scaffolding goal-setting  
• Post goals, objectives, and schedules in an obvious place |
| Support planning and strategy development | 6.2 | • Embed prompts to “stop and think” before acting as well as adequate space  
• Embed prompts to “show and explain your work” (e.g., portfolio review, art critiques)  
• Provide checklists and project planning templates for understanding the problem, setting up prioritization, sequences, and schedules of steps  
• Embed coaches or mentors that model think-alouds of the process  
• Provide guides for breaking long-term goals into reachable short-term objectives |
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| Facilitate managing information and resources          | 6.3        | • Provide graphic organizers and templates for data collection and organizing information  
• Embed prompts for categorizing and systematizing  
• Provide checklists and guides for note-taking |
| Enhance capacity for monitoring progress               | 6.4        | • Ask questions to guide self-monitoring and reflection  
• Show representations of progress (e.g., before and after photos, graphs and charts showing progress over time, process portfolios)  
• Prompt learners to identify the type of feedback or advice that they are seeking  
• Use templates that guide self-reflection on quality and completeness  
• Provide differentiated models of self-assessment strategies (e.g., role-playing, video reviews, peer feedback)  
• Use of assessment checklists, scoring rubrics, and multiple examples of annotated student work/ performance examples |
| Optimize individual choice and autonomy                | 7.1        | • Provide learners with as much discretion and autonomy as possible by providing choices in such things as:  
  • The level of perceived challenge  
  • The type of rewards or recognition available  
  • The context or content used for practicing and assessing skills  
  • The tools used for information gathering or production  
  • The color, design, or graphics of layouts, etc.  
  • The sequence or timing for completion of subcomponents of tasks  
• Allow learners to participate in the design of classroom activities and academic tasks  
• Involve learners, where and whenever possible, in setting their own personal academic and behavioral goals |
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<tr>
<td>Optimize relevance, value, and</td>
<td>7.2</td>
<td>• Vary activities and sources of information so that they can be:                                                                                                           • Personalized and contextualized to learners’ lives                                                                                                                • Culturally relevant and responsive                                                                                     • Socially relevant                                                                                      • Age and ability appropriate                                                                 • Appropriate for different racial, cultural, ethnic, and gender groups                                                                 • Design activities so that learning outcomes are authentic, communicate to real audiences, and reflect a purpose that is clear to the participants                                                                 • Provide tasks that allow for active participation, exploration and experimentation                                                                 • Invite personal response, evaluation and self-reflection to content and activities                                                                 • Include activities that foster the use of imagination to solve novel and relevant problems, or make sense of complex ideas in creative ways</td>
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<tr>
<td>authenticity</td>
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<td>Minimize threats and distractions</td>
<td>7.3</td>
<td>• Create an accepting and supportive classroom climate                                                                                                                                                                              • Vary the level of novelty or risk                                                                                                                                                                                               • Charts, calendars, schedules, visible timers, cues, etc. that can increase the predictability of daily activities and transitions                                                                                       • Creation of class routines                                                                                                                                               • Alerts and previews that can help learners anticipate and prepare for changes in activities, schedules, and novel events                                                                 • Options that can, in contrast to the above, maximize the unexpected, surprising, or novel in highly routinized activities                                                                 • Vary the level of sensory stimulation                                                                                                                                 • Variation in the presence of background noise or visual stimulation, noise buffers, number of features or items presented at a time                                                                 • Variation in pace of work, length of work sessions, availability of breaks or time-outs, or timing or sequence of activities                                                                 • Vary the social demands required for learning or performance, the perceived level of support and protection and the requirements for public display and evaluation                                                                 • Involve all participants in whole class discussions</td>
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| Heighten salience of goals and objectives | 8.1        | • Prompt or require learners to explicitly formulate or restate goal  
• Display the goal in multiple ways  
• Encourage division of long-term goals into short-term objectives  
• Demonstrate the use of hand-held or computer-based scheduling tools  
• Use prompts or scaffolds for visualizing desired outcome  
• Engage learners in assessment discussions of what constitutes excellence and generate relevant examples that connect to their cultural background and interests |
| Vary demands and resources to optimize challenge | 8.2        | • Differentiate the degree of difficulty or complexity within which core activities can be completed  
• Provide alternatives in the permissible tools and scaffolds  
• Vary the degrees of freedom for acceptable performance  
• Emphasize process, effort, improvement in meeting standards as alternatives to external evaluation and competition |
| Foster collaboration and community | 8.3        | • Create cooperative learning groups with clear goals, roles, and responsibilities  
• Create school-wide programs of positive behavior support with differentiated objectives and supports  
• Provide prompts that guide learners in when and how to ask peers and/or teachers for help  
• Encourage and support opportunities for peer interactions and supports (e.g., peer-tutors)  
• Construct communities of learners engaged in common interests or activities  
• Create expectations for group work (e.g., rubrics, norms, etc.) |
| Increase mastery-oriented feedback | 8.4        | • Provide feedback that encourages perseverance, focuses on development of efficacy and self-awareness, and encourages the use of specific supports and strategies in the face of challenge  
• Provide feedback that emphasizes effort, improvement, and achieving a standard rather than on relative performance  
• Provide feedback that is frequent, timely, and specific  
• Provide feedback that is substantive and informative rather than comparative or competitive  
• Provide feedback that models how to incorporate evaluation, including identifying patterns of errors and wrong answers, into positive strategies for future success |
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| Promote expectations and beliefs that optimize motivation | 9.1        | • Provide prompts, reminders, guides, rubrics, checklists that focus on:  
  • Self-regulatory goals like reducing the frequency of aggressive outbursts in response to frustration  
  • Increasing the length of on-task orientation in the face of distractions  
  • Elevating the frequency of self-reflection and self-reinforcements  
  • Provide coaches, mentors, or agents that model the process of setting personally appropriate goals that take into account both strengths and weaknesses  
  • Support activities that encourage self-reflection and identification of personal goals  

| Facilitate personal coping skills and strategies | 9.2        | • Provide differentiated models, scaffolds and feedback for:  
  • Managing frustration  
  • Seeking external emotional support  
  • Developing internal controls and coping skills  
  • Appropriately handling subject specific phobias and judgments of “natural” aptitude (e.g., “how can I improve on the areas I am struggling in?” rather than “I am not good at math”)  
  • Use real life situations or simulations to demonstrate coping skills  

| Develop self-assessment and reflection          | 9.3        | • Offer devices, aids, or charts to assist individuals in learning to collect, chart and display data from their own behavior for the purpose of monitoring changes in those behaviors  
  • Use activities that include a means by which learners get feedback and have access to alternative scaffolds (e.g., charts, templates, feedback displays) that support understanding progress in a manner that is understandable and timely  